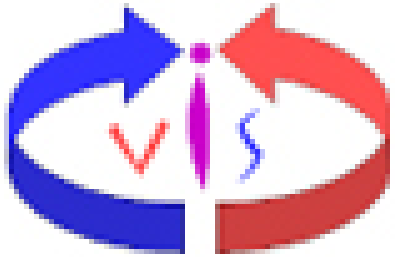

On the Formal Representation of Enemy Courses of Action

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Outline of Talk

- Problem Statement
- Background: ECOAs, JC3IEDM
- Representing ECOAs in JC3IEDM
- Issues with Representing ECOAs in JC3IEDM
- Conclusions

Problem Statement

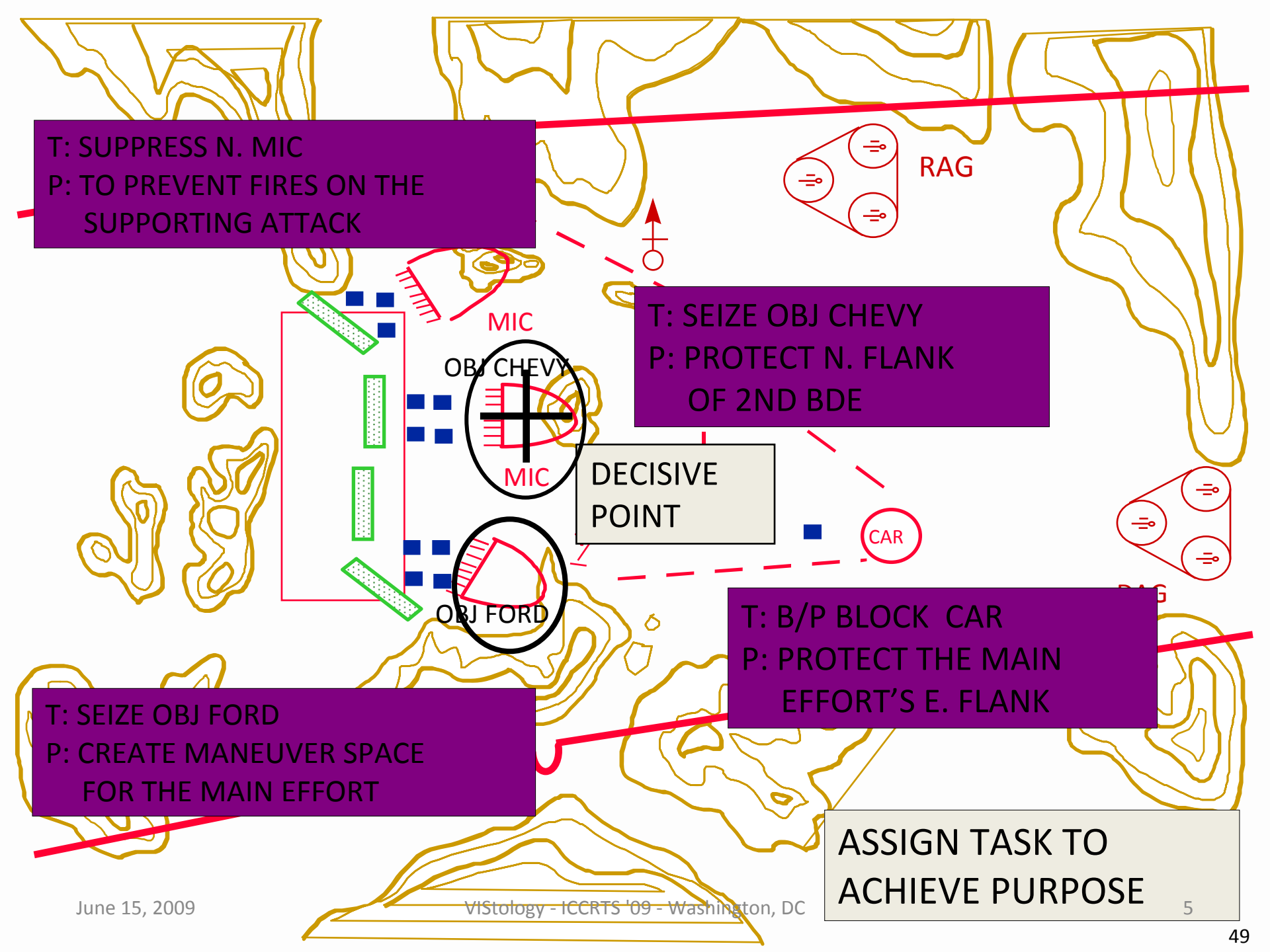
- Information about Enemy Courses of Action (ECOAs) must be shared by coalition forces.
- Potentially, a shared representational language for describing ECOAs is needed that can be used with C4 systems.
- The standard exchange language for sharing such information among NATO forces today is the Joint Command, Control, and Consultation Information Exchange Data Mode (JC3IEDM).
- In this paper we explore the formal representational requirements for describing ECOAs and evaluate the effectiveness of JC3IEDM for this purpose.
- In previous work, we have automatically translated JC3IEDM into OWL (a computationally tractable W3C logical representation that supports ontological reasoning). Aim is to investigate potential for reasoning about ECOAs automatically in C4 systems.

Background: What is an ECOA?

Associated with each ECOA, there is (are):

- **Situation template** which normally consists of a Modified Combined Obstacle Overlay, depicting the operational environment, together with a doctrinal template or model that shows how the enemy would be expected to act in that environment.
- **Time Phase Lines** (TPLs) are placed on the situation template to depict the expected progress of enemy force movements (such as D+1, D+2, etc.).
- A **Situation Matrix** that depicts the expected progress of enemy activity across time in a spreadsheet format may also be used, especially in land-centric operations.
- An **ECOA Narrative Description** accompanies the situation template and usually addresses the earliest time the ECOA could be executed, location of the main effort, supporting operations, time, and phase lines.
- **Decision Points**: critical decisions that the enemy commander must make during implementation of the ECOA are described in terms of their location and space as decision points.
- **High Value Target** list.

Normally at least three ECOAs are briefed: two most likely ECOAs and one most dangerous.


T: SUPPRESS N. MIC
P: TO PREVENT FIRES ON THE SUPPORTING ATTACK
RAG
MIC
OBJ CHEVY
MIC
T: SEIZE OBJ CHEVY
P: PROTECT N. FLANK OF 2ND BDE
DECISIVE POINT
CAR
OBJ FORD
T: B/P BLOCK CAR
P: PROTECT THE MAIN EFFORT'S E. FLANK
T: SEIZE OBJ FORD
P: CREATE MANEUVER SPACE FOR THE MAIN EFFORT
ASSIGN TASK TO ACHIEVE PURPOSE

Background: Elements of ECOA Narrative

- WHAT - the type of operation, such as attack, defend, reinforce, or conduct retrograde
- WHEN – the (earliest) time the action will begin
- WHERE - the sectors, zones, axis of attack, avenues of approach, and objectives that make up the COA
- HOW - the method by which the threat will employ his assets, such as dispositions, location of main effort, the scheme of maneuver, and how it will be supported
- WHY - the objective or end state the threat intends to accomplish

Source: US Army. FM 34-130: "Intelligence Preparation of the Battlefield." Washington, DC. 1994.

Background: Example ECOA Narrative

REDLAND initially conducts joint operations to disrupt JTF [Joint Task Force] Blue Sword forced entry operations, and upon establishment of the JTF Blue Sword in REDLAND, the REDLAND armed forces disperse into small-unit formations in the mountains and cities and initiate insurgency operations to defeat the JTF ground forces.

-from US Naval War College Training Document

Who What When Where How Why

Background: Example ECOA Narrative

REDLAND initially conducts joint operations to disrupt JTF [Joint Task Force] Blue Sword forced entry operations, and upon establishment of the JTF Blue Sword in REDLAND, the REDLAND armed forces disperse into small-unit formations in the mountains and cities and initiate insurgency operations [using IEDs …?] to defeat the JTF ground forces.

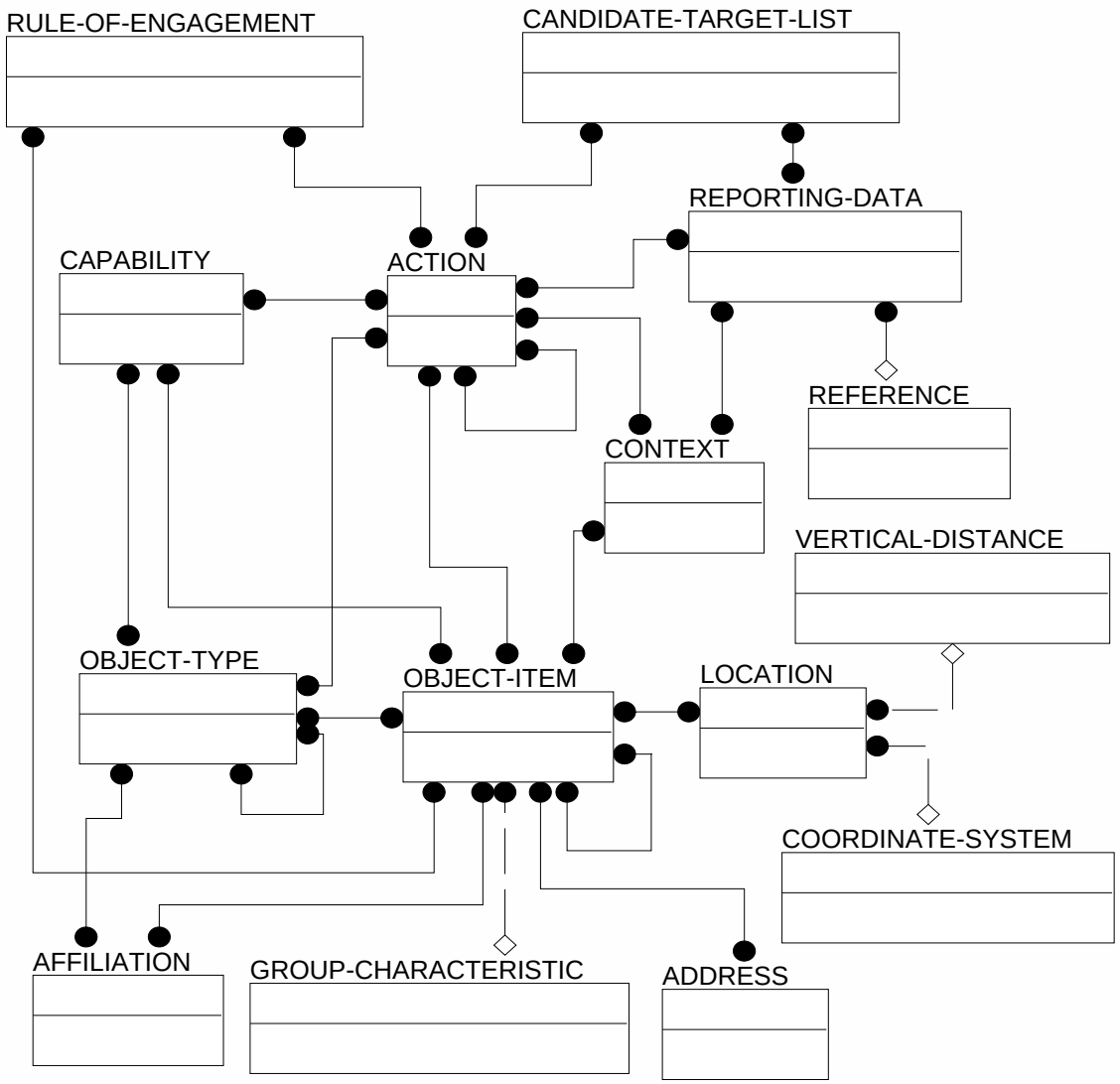
-from US Naval War College Training Document

Who What When Where How Why

Background: What is JC3IEDM?

- Joint Consultation, Command & Control Information Exchange Data Model (JC3IEDM)
  - Generic Hub -> Land C2IEDM -> C2IEDM -> JC3IEDM
- Developed by the Multinational Interoperability Programme (MIP)
  - NATO organization
  - Goal: international interoperability of C2IS to support multinational (NATO) combined and joint operations
- Relational Data Model for Information Exchange
  - 289 entities
  - 396 relationships between entities
  - 1729 entity attributes
  - nearly 7000 value codes

Background: JC3IEDM



ECOAs in JC3IEDM: JC3IEDM ACTIONs

is-placed-within /	ACTION-CONTEXT	Where (Context)
is-measured-by / records-observed-results-of	ACTION-EFFECT	
is-the-subject-of /	ACTION-FUNCTIONAL-ASSOCIATION	Why
is-the-object-of /	ACTION-FUNCTIONAL-ASSOCIATION	
is-focussed-on / is-focus-of	ACTION-OBJECTIVE	What (1 of 2)
requires-as-a-minimum / is-minimum-required-for	ACTION-REQUIRED-CAPABILITY	
has/is-ascribed-to	ACTION-STATUS	How (Degree)
requires / is-required-for	ACTION-RESOURCE	How (Instrument)
is-the-subject-of /	ACTION-TEMPORAL-ASSOCIATION	When
is-the-object-of /	ACTION-TEMPORAL-ASSOCIATION	
is-acted-upon-as-specified-by /	ORGANISATION-ACTION-ASSOCIATION	Who
is-the-reason-for / is-based-on	OBJECT-ITEM-GROUP-ACCOUNT	
has-relevant-information-in /	ACTION-REFERENCE-ASSOCIATION	See Also
is-geometrically-defined-through /	ACTION-LOCATION	Where (Physical)
has	action-id (PK)	
has	action-category-code	What (2 of 2)

JC3IEDM Action-Tasks/Action-Events and Time

Action-Tasks are actions with known planning. These include:

(45 shared with ACTION-EVENT)

Attack, Courier, Cover, Cross, Dazzle, Debar,k Deceive, Deception, electronic Decontamination services, Defeat, Defence destruction, Defence suppression Defend Defensive counter air Deflect Delay Demolish Deny Deploy Describe Destroy Detect Disengage Disrupt Distribute Dive Divert Drone launch Dumping Electronic counter measures Electronic warfare Electronic warfare support Embark Engage

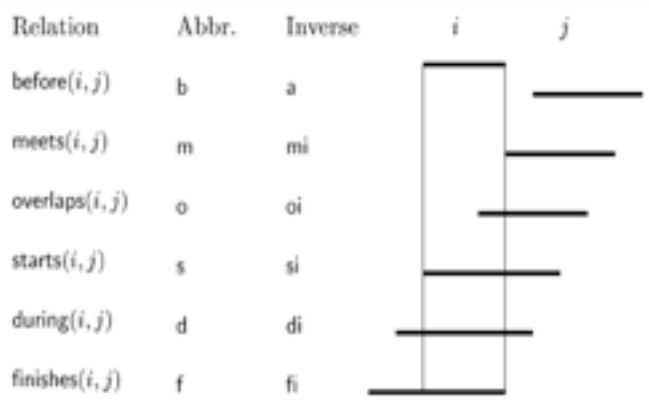
Action-events have no known associated planning. Types include:

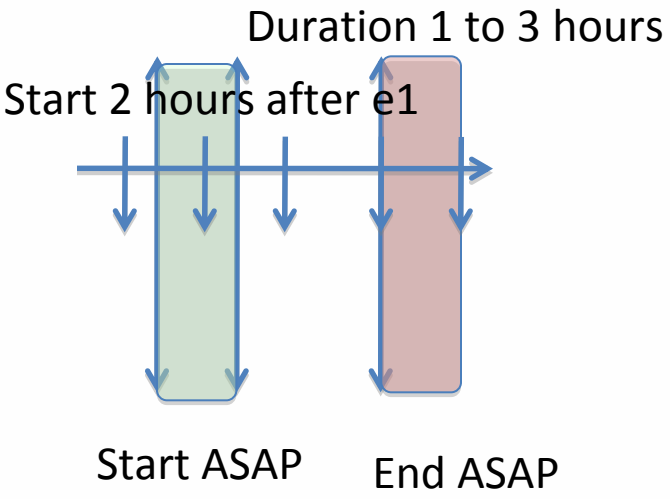
Publishing press release, Pursuing, Rape, Reconnaissance, Reconnaissance in force, Reconstituting Recovering Recuperating Redeployment Refugee movement Reinforcing Relief in place Religious demonstration Religious violence Religious warfare Rendezvous Reorganising Repairing Resting Resupplying

JC3 Actions have:

1. Planned start/end times (Tasks)
2. Start/End times can be qualified:
   - continue until further notice, ASAP (after), no later than TIME.
3. Temporal relations to other events (± interval)
4. Status-completion-codes (ratio); so it is possible to say – A begins when B is ½ done.
5. Reporting times
6. Progress-codes
   - completed, paused, in progress, not started
7. Minimum duration
8. Maximum duration
9. Expected duration
10. Action-task-timing-hour-code (e.g. H hour)
11. Action-task-timing-day-code (e.g. D day)

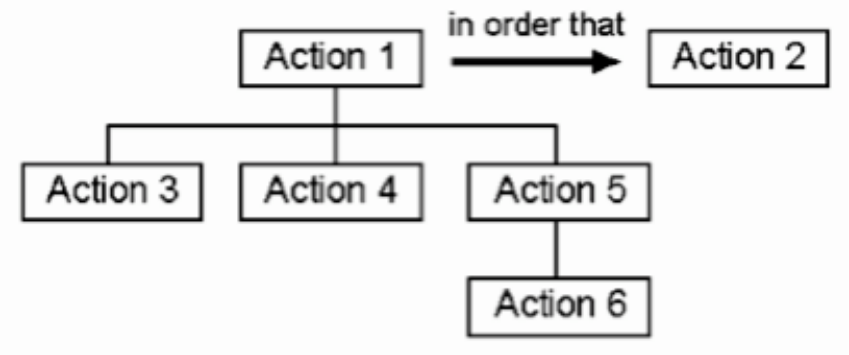
Inferences





- In JC3IEDM, events can have underspecified start and end times (e.g. 2 hours after end of another event; or H-hour + 2; or ASAP).
- Duration can be encoded as a min-max range with an expected value, or projected via a completion ratio.
- JC3IEDM also allows relationship based on completion ratios: Action A begins … before/after Action B is 1/3 completed.
- OWL-TIME can provide semantics of basic JC3IEDM temporal relations (VIStology, Fusion ‘09)

Event Structure: Composition, Ordering, Means and Purpose Clauses



JC3IEDM supports complex ACTION mereology and functional/temporal relations

X disrupted the elections *by bombing the polling place*.

The disrupting ACTION has sub-ACTION bombing (means).

Purpose clauses represented by ACTION functional association *in-order-that*

Issue 1: Limitations of JC3IEDM ACTION-TASK Activity Codes

Not All Are Verbs

- e.g. air assault (nominalization), air defense, air superiority (state), amphibious operation

Of ~50 ECOAs that we've identified (descriptions of enemy activities from military sources), many involve actions that don't have a close equivalent in JC3IEDM:

- Make propaganda claim, dig up, create environmental hazard, escape, signal, store, protect, disguise, seek safe haven, load, smuggle, steal, forge, finance, tip off
- In other cases, paraphrase is loose
  - emplace -> deploy; park -> deploy; detonate suicide vest -> suicide, explode; kill -> murder, execute,

Some don't describe particular activities, but activities grouped by purpose

- E.g. "information operations"
- To conduct an operation that includes actions to influence decision makers in support of political and military objectives by affecting other's information, information based processes…

No hierarchy or relations among activities:

- Cross entails Move
- But Move, Cross and Traverse different, unrelated activities in JC3IEDM

Capture is an ACTION-TASK (planned), but not Murder or Intimidate or Explode (IED, suicide vest)

- ACTION-TASKS are defined from Blue perspective.
- ACTION-EVENT types include more Red activities

Issue 2: Group Actors and Distributivity

Group Actors:

Jack and Jill (as a group) captured the hill.

Group action requires group entities or plural quantification.

In JC3IEDM:

ORGANISATION O

O *has-org-structure* OS

OS *includes* Jack

OS *includes* Jill

Also: X kidnapping Shi'a

Focus of ACTION Kidnap is Person-Type Shi'a.

Distributivity requires rules:

Jack and Jill went up hill (distributive)

|= Jack went up hill.

Ships 1…10 blockaded harbor (non-distributive)

|≠ Ship 1 blockaded harbor

Distributity is predicate- and context-specific.

JC3IEDM has no means to distinguish distributive and non- distributive predicates.

Issue 3: Negative Events and Feints

JC3IEDM:

Cannot encode explicitly: it is not the case that X is Y-ing.

But can infer by closed-world assumption (negation as failure)

BUT: Every ACTION-TASK can be marked ‘feint’.

If X feigns Y-ing, then

X gives false appearance of Y-ing, but X is not Y-ing.

Cannot infer contradiction between reports of Y-ing and feigning to Y in JC3IEDM. (Would require an inference rule.)

Issue 4: Quantification and Disjunction

ECOA: “The REDLAND armed forces disperse into small-unit formations in the mountains or cities and initiate insurgency operations to defeat the JTF ground forces.”

JC3IEDM:

Pure first-order relations; no universal quantification

That is, can’t say, for every element x of Redland, either x goes to mountain or x goes to city.

Disjunction can be represented as *alternative* ACTION functional relation.

That is, can say “Redland forces disperse…into mountains; ALTERNATIVELY, they disperse into city”.

This is not semantically equivalent, however.

Conclusions

Positive

JC3IEDM

1) Enables the encoding of a range of Who/What/When/Where/How/Why/See Also information for ECOA Narrative Descriptions of considerable complexity.
2) JC3IEDM has been translated into OWL; so reasoning is theoretically possible (with some caveats).

Negative

JC3IEDM

1) does not currently contain a sufficiently rich vocabulary of activity types when dealing with irregular warfare,
2) is not able to deal with all aspects of quantification,
3) cannot adequately represent disjunctions and distributivity and
4) is unable to represent the negation of something occurring now or in the future.

Thank You

Questions?

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ECOA Elements	JC3IEDM	SAW-CORE	Situation Theory	STO
Who (aggregate agents)	JC3IEDM ORGANISATION with specified role; supports aggregate agents for joint action;	Any instance of OWL:Thing; Situation Object can be aggregate of multiple objects.	Both aggregates and their members are of type IND; membership is a relation.	Aggregates are a subtype of STO:INDIVIDUAL; membership specified as property.
What (feints; negative events, quantified events; closed/open world (non-)distributive actions; extrinsic references)	One of specified ACTION EVENT or ACTION-TASK types; supports feints, but no negative events; Closed world. No quantification; no distributivity qualifier on actions; info can be provided extrinsically	Any binary relation of OWL:Things, possibly specified as a dynamic system; limited quantification; no feints; no negative infons; Open world; distributivity requires rules; extrinsic information via rdfs:seeAlso	Any n-ary relation of individuals. Negative infons; no feints; Partial world; Full quantification. Distributivity rquires subtyping relations and *involves* relation; Extrinsic information could be specified as a relation.	Any binary relation of OWL:Things, possibly specified as a dynamic system; limited quantification; no feints; negative infons but limited inferences; Open world; distributivity requires rules; Extrinsic info via rdfs:seeAlso
When (Absolute/relative)	Absolute and relative time w/respect to ACTIONS and their stages	SAW-CORE:Attribute - Absolute time expressed in OWL	Any element of type TIM	Absolute time instant expressed in OWL as e.g. STO:Time
Where	JC3IEDM LOCATION; Geophysical points and regions	SAW-CORE:Attribute - Location expressed in OWL	Any element of type LOC	Geophysical point STO:Location expressed in OWL
How/Why (means clauses; purposes clauses)	Sub-Actions and functional relations; ACTION-OBJECTIVE	No means clauses; Specified Goal Relation(s).	No means clauses; Goals require representing intentional states.	Unspecified.